DOCUMENT RESUME

ED 228 052 SE 040 928

TITLE	High School Mathematics Preparation in Michigan: Assets and Liabilities. Guidelines for Quality Mathematics Teaching. Monograph No. 14.
INSTITUTION	Michigan Council of Teachers of Mathematics.
PUB DATE	Sep 79
NOTE	43p.
AVAILABLE FROM	MCTM, Box 16124, Lansing, MI 48901 ($1.50).
PUB TYPE	Reports - Research/Technical (143) -- Guides - Non-Classroom Use (055)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Career Awareness; College Freshmen; *College Mathematics; *Course Descriptions; Educational Research; *Enrollment; Error Patterns; Guidelines; Higher Education; Mathematics Achievement; *Mathematics Instruction; Remedial Instruction; *Remedial Mathematics; Secondary Education; *Secondary School Mathematics; Student Characteristics; Surveys
IDENTIFIERS	*Mathematics Education Research; Michigan

ABSTRACT

To assess enrollment trends in Michigan colleges and universities, two surveys were conducted in 1976 and 1977. Community colleges reported either fairly constant enrollments in remedial courses or slight increases; many of their students had always needed remedial work. For four-year institutions, increases were often dramatic. This is paralleled by data on a national level. Downward trends on the ACT, SAT, and NAEP tests were noted, although Michigan students' scores generally were higher than the national norm. High school mathematics needed for careers is tabulated, along with an estimate of supply and demand for college graduates. In the third chapter of the monograph, freshman mathematics courses are described, criteria for placement are noted, a profile of the high school academic background of remedial students is given, and mathematical weaknesses of entering college freshmen are detailed. Characteristics of underprepared students as seen by college faculty, high school teachers, and students are listed in the next chapter. Finally, six recommendations are made as steps that might be taken by all persons involved in the educational process. (MNS)

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INTRODUCTION

Origins: The topic for discussion at the February 4, 1977 Leadership Conference, jointly sponsored by the School of Education and the Department of Mathematics of The University of Michigan and the Michigan Council of Teachers of Mathematics, was "Back to Basics in Mathematics--What it Means for Curriculum, for Teaching, for Learning." At this conference Elizabeth Phillips and Glenda Lappan of Michigan State University led a discussion group concentrating on college level entrance "Basics." Out of this group came a recommendation that 1) specific statistical information concerning the state of preparedness of entering college students, 2) specific information on placement exams and remedial courses at the college level, and 3) recommended actions which could be taken by all teachers and administrators concerned with mathematics, be organized and disseminated through the MCTM in the form of a monograph. The following committee[1] was established to carry out this recommendation:

Jerry Brantley
Department of Mathematics
Macomb County Community College

Eugene Krause
Mathematics Department
The University of Michigan

Douglas Reinhard
Mathematics Department
Bloomfield Hills Andover
High School

Glenda Lappan, Co-Chairperson
Mathematics Department
Michigan State University

Elizabeth Phillips, Co-Chairperson
Mathematics Department
Michigan State University

Jo Anne Rankin
Mathematics Department
Eastern Michigan University

[1]The term committee throughout this monograph refers to this group.

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CHAPTER I

THE STATE OF MATHEMATICS PREPAREDNESS OF ENTERING FRESHMEN IN MICHIGAN COLLEGES

Over the past decade the enrollment in Michigan colleges increased to record highs and then in many cases leveled off or began to decline. During the same period enrollment in college mathematics courses steadily increased, even in colleges with declining overall enrollments. The increase in mathematics enrollments was primarily at the freshmen and sophomore levels (many of these in pre-college level mathematics courses).

1.1 MICHIGAN PATTERNS OF ENROLLMENT IN COLLEGE MATHEMATICS

The 1976 Survey: In order to assess the enrollment trends in Michigan colleges and universities, the committee conducted two surveys, one in the fall of 1976 and one in the fall of 1977. In the 1976 survey, questionnaires were sent to the four-year, degree granting, state institutions and a sample of community and junior colleges in Michigan. Seven community colleges and seven four-year, degree-granting colleges or universities responded. The questionnaire requested enrollment data for remedial mathematics (defined to be courses of a level lower than College Algebra), for total mathematics enrollment, and for trends in the enrollment figures for remedial courses since 1970.

The seven community colleges reported either fairly constant enrollments in remedial courses or slight increases ranging from 2% to 10% per year over the last several years. A number of the community college respondents pointed out that a high percentage of their students had always fallen into the remedial mathematics category. The 1976 survey presented quite a different picture for the responding four-year colleges and universities. Here the percent of increase in remedial enrollments over the past few years ranged from 4% per year to an extreme case of 300% per year (where remedial enrollments are a new problem). Table 1.1 presents summary data for the survey.

Table 1.1

1976 Fall Enrollments in Remedial Math

	Remedial	Total	% in Remedial
1976 Community Colleges	4195	6824	61.5
1976 Four-Year Colleges	4969	29425	16.9

The 1977 Survey: In the fall of 1977 the committee sent a letter to all four-year state colleges and universities and to the larger community colleges in Michigan. Twenty-three letters were sent and thirteen responses were received. Nine of these were four-year institutions and four were community colleges.

The respondents to this survey included five four-year colleges and two community colleges which did not respond to the 1976 survey. The two surveys together contain information from 21 different colleges and universities in Michigan.

The results of the 1977 survey are given in Table 1.2.

Table 1.2

Mathematics Enrollments in
4-Year and 2-Year Michigan Colleges

	Below Calculus	Calculus	Total	% in Below Calculus
1970	12031	6864	18895	63.7
1977	19659	7927	27586	71.3
Percent Increase	63.4	15.5	46.0	

The increase for the pre-calculus group from 1970 to 1977 is 63% as contrasted with 15% increase in calculus enrollments.

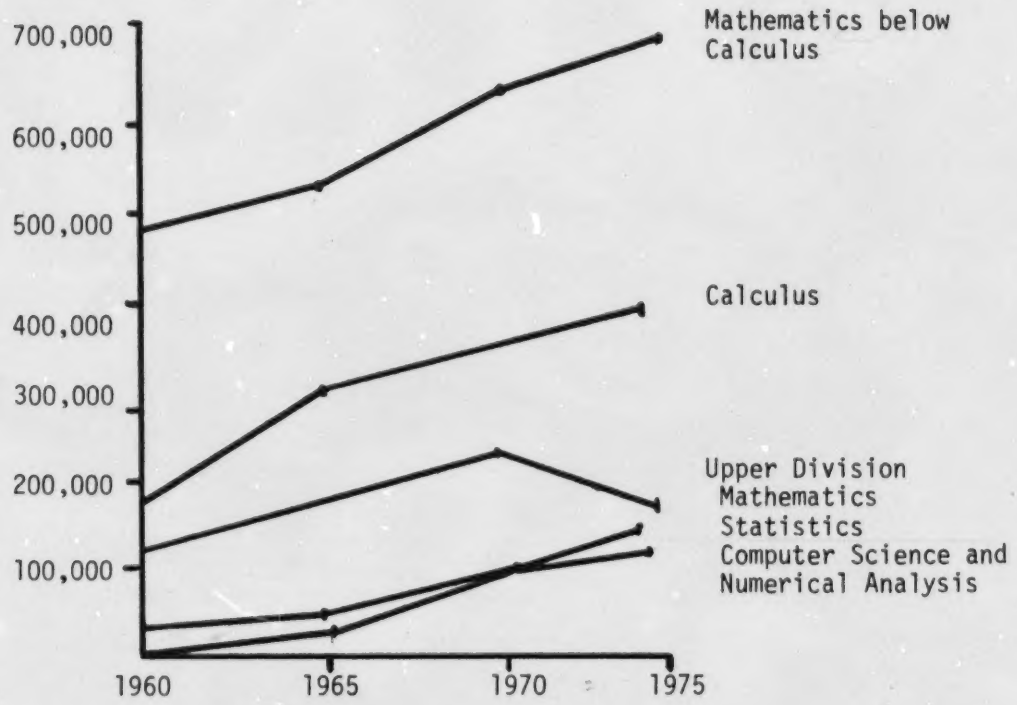
Both surveys indicate that enrollments in pre-calculus and calculus classes were increasing and that remedial math constituted a substantial part of the pre-calculus enrollments.

1.2 NATIONAL PATTERNS OF ENROLLMENT IN COLLEGE MATHEMATICS

Figure 1.3 gives the national picture of mathematics enrollments from 1960 to 1975 as reported in "Undergraduate Mathematical Sciences in Universities, Four-Year Colleges, and Two-Year Colleges, 1975-76", CBMS - Vol. V. This graph tends to corroborate the Michigan trend in college mathematics enrollments; calculus and, most definitely, below calculus courses experienced increased enrollments, while upper division mathematics courses showed declining enrollments.

Figure 1.3

Mathematical Science Enrollments in
Universities and Four-Year Colleges
1960-1975



On a national scale in 1976, Dr. Karl Lindberg[1] of Wayne State University sent one thousand questionnaires to departments of mathematics throughout the United States concerning the nature of preparatory (remedial) mathematics. Forty-seven percent of the questionnaires were returned, and a large percentage indicated that a substantial portion of the professional energies of mathematics departments was devoted to preparatory mathematics. It was found that three-fourths of the surveyed departments had preparatory mathematics programs, and that in 81% of these departments at least one-tenth of the total enrollment was in preparatory mathematics.

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[1]Unpublished paper: Preparatory Mathematics Programs in Departments of Mathematics, Karl Lindberg, Department of Mathematics, Wayne State University, November, 1976.

1.3 NATIONAL AND MICHIGAN TEST SCORES

The lack of mathematics preparedness is also reflected in the striking downward trends in academic achievements and skills which have been reported over the past decade as a result of large scale testing efforts such as the American College Testing Service (ACT), the Admissions Testing Program of the College Entrance Examinations Board (ATP-SAT) and the National Assessment of Educational Progress (NAEP).

There has been a great deal of discussion concerning the causes of the declining test scores. (See the bibliography for sources). For whatever cause, the fact remains that test scores have declined.

In Figures 1.4, 1.5, 1.6, and 1.7 a comparison is made between Michigan students and the national population of ACT and SAT test takers.

It should be noted that in both tests Michigan students tended to do better both mathematically and verbally than the national population. However, Michigan students have followed the national trend of decreasing test scores. Figures 1.4 and 1.5 show an increase for both groups in the ACT math and verbal scores for 1976-77; while this increase is encouraging it is too early to make any generalizations.

On the SAT graphs, Figures 1.6 and 1.7, Michigan students' scores generally increased while the national scores have decreased. This may be in part due to the changing population of SAT test takers in Michigan. Most Michigan colleges accept ACT scores for scholarship consideration while many eastern and liberal arts colleges continue to require the SAT scores. This is demonstrated by the fact that in Michigan in 1972 over 26,000 students took the SAT while 33,000 took the ACT. In 1976 about 20,000 students took the SAT compared to 54,000 students taking the ACT in Michigan.

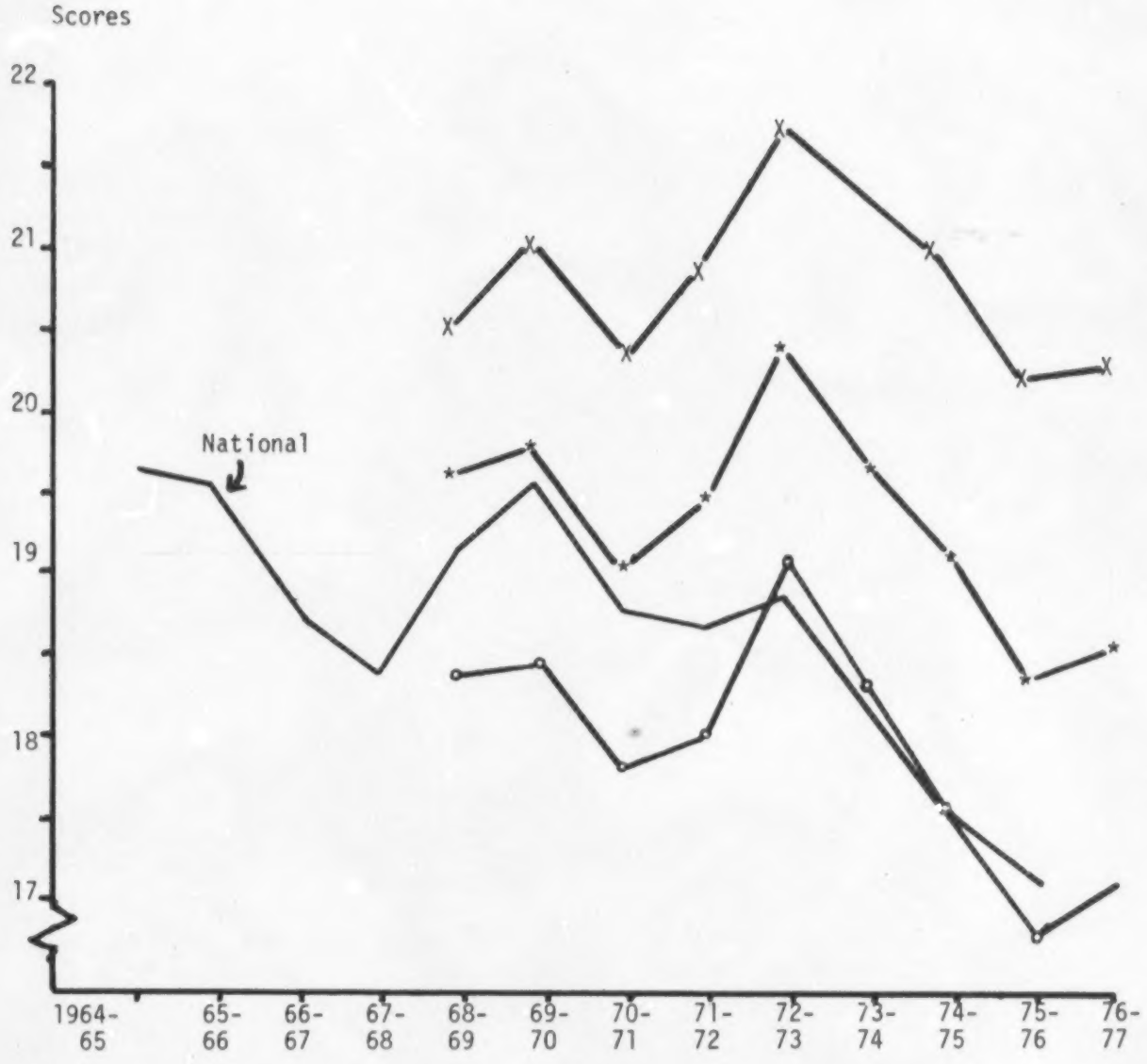

Figure 1.4 - ACT-Math
* Michigan Students
X Michigan Males
o Michigan Females

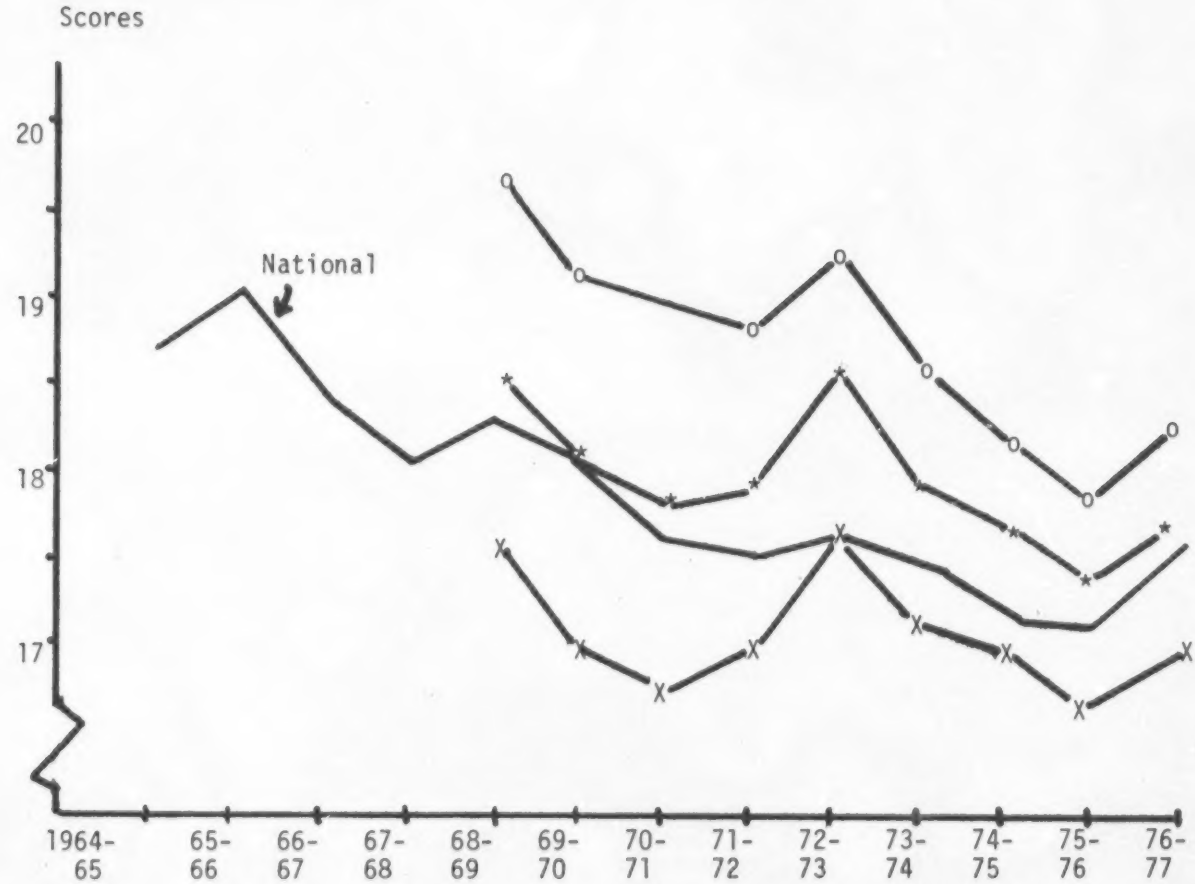

Figure 1.5 - ACT-English
* Michigan Students
X Michigan Males
o Michigan Females

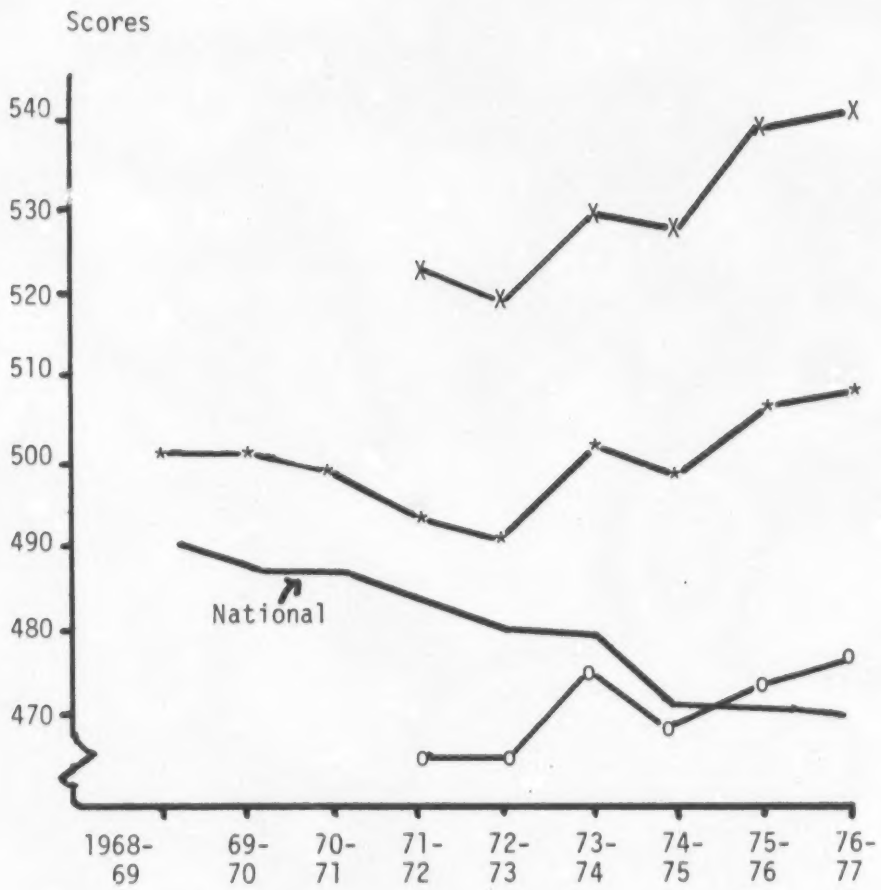

Figure 1.6 - SAT-MATH
* Michigan Students
X Michigan Males
o Michigan Females

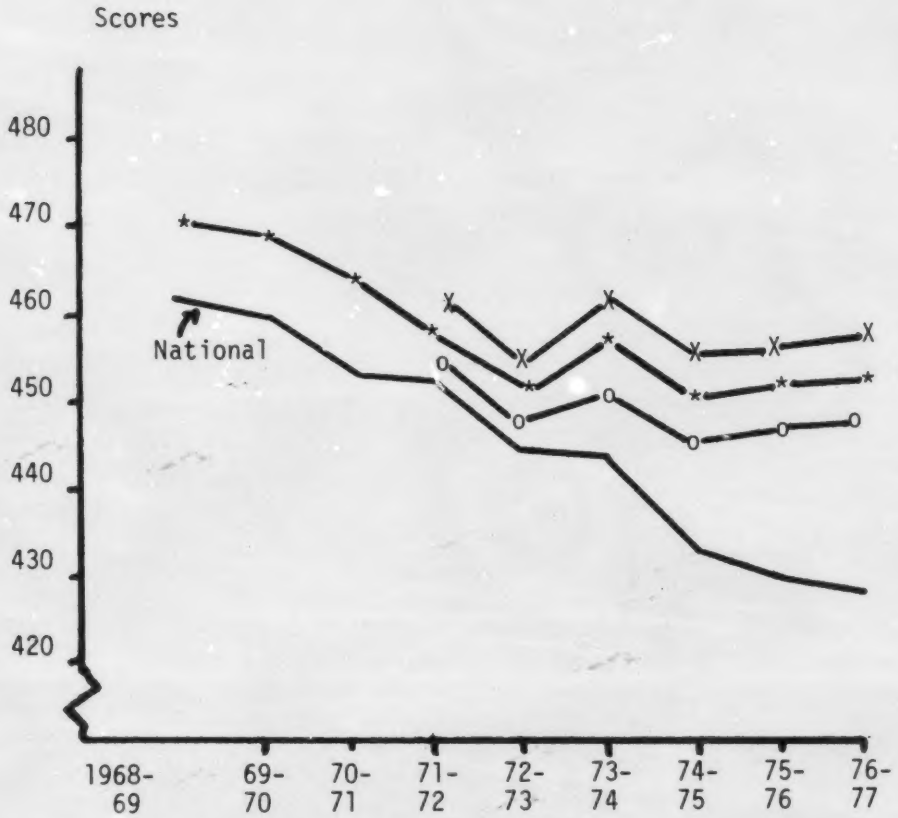

Figure 1.7 - SAT-VERBAL
* Michigan Students
X Michigan Males
o Michigan Females

CHAPTER II

MATHEMATICS, CAREERS, AND JOBS

One of the many significant factors leading to the increased mathematics enrollments is the rising level of mathematical competence required by a variety of college majors as, for example, business. There are few academic or professional majors at present that do not have a mathematics requirement, and those majors which do not require mathematics are, for the most part, in areas where the supply of job seekers is greater than the number of jobs available. Hence, we are faced with a situation where a rapidly growing number of Michigan students, while satisfying the minimal college entrance requirements in mathematics, find themselves, once in college, facing increasing mathematics requirements in many college majors. Many of these students find themselves ill-prepared to satisfy these more substantial mathematics requirements.

2.1 CAREERS

Mathematics has always been essential for careers in science, engineering, and business. In recent years many other fields have come to require mathematics as well. Often the mathematics requirement is an implicit one. For example, to be a psychologist one needs to know statistics, which presupposes a background in mathematics. To be a physical therapist one must understand basic physics, which again relies on mathematics. Tables 2.1 and 2.2 below list the high school mathematics courses that are required for various careers.

Table 2.1 covers fields that are usually associated with vocational-technical institutes. In this table required courses are denoted by an "R" and desirable courses by a "D". The table is based on a brochure prepared by the Minneapolis Public Schools. The requirements listed seem somewhat milder than they might be. For example, geometry is not listed as required for illustrators, artists, opticians, or machinists. One could certainly argue about those omissions.

Table 2.2 lists majors that are normally offered in colleges and universities. This table is a combination of data from a Mathematics Association of America leaflet and from Michigan State University. The MAA leaflet, "The Math in High School You'll Need for College", would be a

useful item to have available to students through their high school mathematics teachers or counselors. Limited quantities may be requested from:

The Mathematical Association of America
1225 Connecticut Avenue, N.W.
Washington, D.C. 20036

Table 2.1

High School Mathematics Needed for Vocational Technical Careers

	Algebra	Geometry	Advanced Algebra	Trigo-nometry	Analysis
Law Enforcement Officer	D				
Floor Covering Installer	D	D			
Pilot	R	R	R	R	R
Air Traffic Controller	R	R	R	R	
Interior Decorator	D	D	D	D	
Medical Stenographer	D				
Illustrator	D	D			
Optician	R	D	D	D	
Cabinetmaker	D	D			
Flight Engineer	R	D	D	D	
Artist	D	D			
Electrician	R	D	D	D	
Plumber	D	D			
Surveyor	R	R	R	R	
Air Frame and Power Plant Mechanic	R	R			
Radio Technician	R	D	D	D	
Draftsperson	R	R	R	R	R
Jeweler	D	D	D	D	
Medical or Dental Asst. (Hygienist)	D	D	D	D	
All-around Machinist	R	D			
Map-Maker	R	R	R	R	
Tool and Die Designer	R	R	D	D	
Construction Inspector	R	R			
Radio Operator	R	D	R	R	
Computer Service Technician	D	D	D	D	

D = Desirable
R = Required

Table 2.2

High School Mathematics Needed for Collegiate Majors

	Algebra	Geometry	Advanced Algebra	Trigonometry	Analysis
Agriculture:					
Agricultural Economics	R	R	R		
Entomology	R	R	R		
Environmental Sciences	R	R	R	R	R
Food Sciences	R	R	R		
Forestry	R	R	R		
Fisheries and Wildlife	R	R	R	R	R
Genetics	R	R	R		
Landscape Architecture	R	R	R		
Plant Pathology	R	R	R		
Rural Sociology	R	R	R		
Wildlife Ecology	R	R	R		
Other area of agriculture	R	R			
Architecture	R	R	R		
Art	R	R			
Business:					
Accounting	R	R	R		
Banking	R	R	R	R	R
Economics	R	R	R	R	R
Management	R	R	R	R	R
Marketing	R	R	R	R	R
Communications	R	R			
Speech and Audiology	R	R	R		
Education:					
Elementary	R	R	R		
Child Development and Preschool	R	R	R		
Science or Mathematics Teacher	R	R	R	R	R
Engineering	R	R	R	R	R
History	R	R			
Language and Literature	R	R			
Law	R	R	R		

D = Desirable
R = Required

Table 2.2 (Continued)

	Algebra	Geometry	Advanced Algebra	Trigo-nometry	Analysis
Life Sciences:					
Bacteriology	R	R	R	R	R
Biochemistry	R	R	R	R	R
Biology	R	R	R	R	R
Biophysics	R	R	R	R	R
Microbiology	R	R	R	R	R
Physiology	R	R	R	R	R
Zoology	R	R	R	R	R
Linguistics	R	R	R		
Mathematics Sciences:					
Mathematics	R	R	R	R	R
Statistics	R	R	R	R	R
Actuarial Sciences	R	R	R	R	R
Computer Science	R	R	R	R	R
Medicine:					
Allied Medicine	R	R	R		
Dental Hygiene	R	R	R		
Dentistry	R	R	R	R	R
Medical Technology	R	R	R	R	R
Nursing	R	R	R		
Nutrition	R	R	R	R	R
Optometry	R	R	R	R	R
Physical Therapy	R	R	R		
Pre-medicine	R	R	R	R	R
Public Health	R	R	R		
Speech Pathology	R	R	R		
Music	R	R			
Pharmacy	R	R	R	R	R
Philosophy	R	R			
Physical Sciences:					
Astronomy	R	R	R	R	R
Chemistry	R	R	R	R	R
Geology	R	R	R	R	R
Physics	R	R	R	R	R

D = Desirable
R = Required

Table 2.2 (Continued)

	Algebra	Geometry	Advanced Algebra	Trigonometry	Analysis
Social Sciences:					
Anthropology	R	R			
Asian Studies	R	R			
Black Studies	R	R	R		
Geography	R	R	R		
Political Science	R	R	R		
Psychology	R	R	R	R	R
Social Welfare	R	R			
Sociology	R	R	R		
Theater	R	R			
Veterinary Medicine	R	R	R		

2.2 JOBS

It would be foolish for a person to choose a career solely on the basis of employment prospects, present or projected. Yet it would not be wise to ignore the job market entirely either. The following quotation, from The University of Michigan Placement Bureau memo to counselors at The University of Michigan, indicates clearly the importance of mathematical training in securing a job.

"The occupational outlook for the next ten years is that the employment picture for traditional service occupations requiring humanities and non-quantitative social science backgrounds will get worse. The employment picture for individuals with math and computer science exposure and in technological areas will remain favorable and should even improve during the period. Currently campus recruiters for business and industry across the country are looking for some mathematics background in most job applicants. One study showed that 31% of all recruiters from business/industry had a minimum requirement of one calculus course...Sixty percent of the recruiters felt job applicants should have completed at least one math course (not necessarily calculus) in college, or be able to demonstrate that they were not 'anxious' when confronted with quantitative tasks. Only 9% of the recruiters from business and industry did not stress math training...The oversupply of college graduates relative to the demand for the college educated is approximately 80,000. The gap between supply and demand is most

acute for those trained in the humanities and social sciences. Those with natural science, business, or engineering degrees fare better."

Support for this picture of generally bright prospects in mathematical areas and bleak prospects in non-mathematical areas is provided by the data in Table 2.3. Notice that all fields in which demand exceeds supply are in some sense mathematical, while nearly all fields in which supply exceeds demand are non-mathematical. Note also that, even within over-supplied categories such as education and social sciences, sub-specialities, such as mathematics teachers and social statisticians, are generally under-supplied. Again the mathematics background improves the job possibilities.

2.3 WHY ME AND WHY NOW?

Some students are "certain" they won't need any mathematics because their chosen careers don't require any. Aside from the obvious point that career plans change as one gets older, there is another important consideration. Currently only 35% of liberal arts college graduates secure an entry level job specifically related to their college major. That is, 65% of the liberal arts graduates are forced to venture into occupations unrelated to their field of concentration. These new occupations might very well require quantitative skills. The history major who ends up working in an office might rue the day he/she decided no more mathematics was needed.

Other students stop electing high school mathematics on the grounds that if they find out later that more mathematics is needed, then they will take it in college. There are a number of reasons why this usually is a poor policy. Here are a few. Remedial math courses offered in college often carry reduced academic credit or no academic credit at all, and paying college tuition costs for no credit is uneconomical. Typically a college course covers in one semester or term what a high school course covers in a full year. The accelerated pace, combined with the lack of individual attention because of large class sizes, can overwhelm weaker students. The percent of students requiring substantial remedial work that graduate from college is less than 40%, and many of the graduates take five years or more to do so. It is clearly preferable to take high school level courses in the high school, at a reasonable pace, and in a class that is small enough to allow some personal attention.

In order to have a real <u>choice</u> of college majors and career goals, students must keep their options open by studying and mastering mathematics in high school.

Table 2.3

Estimated Supply and Demand
1976-77 College Graduates

Bachelor Degrees Only

Demand Exceeds Supply	Number	Percentages
Computer and Information Services	5,640	0.6
Physical Sciences	20,380	2.1
Accounting	36,410	3.8
Health Services	45,010	4.7
Engineering	50,570	5.3
Other Business and Management	99,170	10.4
	257,180	26.9
Supply and Demand about Equal		
Library Science	1,260	0.1
Architecture and Environmental Design	8,470	0.9
Public Affairs	25,990	2.7
Agriculture	15,930	1.7
Mathematics and Statistics	19,940	2.1
Biological Sciences	47,340	5.0
Communications	19,200	2.0
Other	45,290	4.8
	183,420	19.3
Supply Exceeds Demand		
Foreign Languages	18,110	1.9
Fine and Applied Arts	40,320	4.2
Psychology	57,740	6.1
Letters	63,180	6.6
Education	183,010	19.2
Social Sciences	149,040	15.7
	511,400	53.7

Note: Columns may not total 100% due to rounding.
Data adapted from National Center for Educational Statistics.
Supply and demand ratio estimated by John D. Shingleton, Michigan State University.

CHAPTER III

FRESHMAN MATHEMATICS COURSES AND THE REMEDIAL STUDENT

3.1 DESCRIPTION OF FRESHMAN MATHEMATICS COURSES

Although colleges and universitites in Michigan vary in their freshman mathematics offerings, the following courses or amalgamations of them are widely offered.

Remedial Courses

1) Arithmetic: Usually one term or semester.

Course Description: The base 10 numeration system; rounding and estimating; fractions; decimals; percent; equations; formulas; proportion; multiplication and division by powers of ten and their multiples; scientific notation.

2) Elements of Algebra I: One term or semester.

Course Description: Addition, subtraction, multiplication, division of signed numbers and fractions; use of parentheses; addition, subtraction, multiplication and simple factoring of polynomials; properties of integer exponents; addition, subtraction, multiplication and division of rational algebraic expressions; solving linear equations and verbal problems involving linear equations; graphing linear equations.

3) Elements of Algebra II: One term or semester

Course Description: A quick review of operations with addition, subtraction, multiplication and factoring of polynomials; simple inequalities; absolute value; operations with rational algebraic expressions; addition, subtraction, multiplication and division of complex fractions; rational exponents and radicals; linear and quadratic equations; verbal problems involving linear and quadratic equations; graphing of linear and quadratic equations; a brief introduction to polynomial functions-domain, range and graphing.

These courses are intended for (1) students with little or no previous background in algebra, (2) students who have not had any algebra for some time (e.g., "I had Algebra I in high school four years ago and I really didn't understand it."), or (3) students who want a "fresh start" in algebra. In many schools, college credit is not given for these courses even though students must pay tuition fees to take them. In other schools some college credit toward graduation is given, but the credit seldom is counted toward the requirement of any college major.

Regular Credit (full or partial) Offerings

1) College Algebra and Trigonometry: A two term or semester sequence for students who have mastered 1½ years of high school algebra and one year of geometry.

Part (A) College Algebra

Course Description: Inequalities and absolute values; exponents; functions (domain, range, graphing, etc.); exponential and logarithmic functions; complex numbers; solving quadratic equations and equations in quadratic form; synthetic division; theory of polynomial equations; systems of equations using matrices and determinants.

Part (B) Trigonometry

Course Description: Trigonometric functions; identities; graphs, equations; triangle solutions; mathematical induction; straight line analytic geometry; vectors.

2) College Algebra with Trigonometry (Pre-Calculus or Elementary Functions): A one-term or semester course for students with some high school trigonometry and at least 1½ years of algebra and one year of geometry.

Course Description: Inequalities and absolute value; functions (domain, range, graphing, etc.); review of logarithmic and exponential functions; trigonometric functions; identities, graphs and equations; systems of equations; matrices and determinants; inverse functions; systems of linear inequalities and their applications; binomial theorem; arithmetic and geometric series; mathematical induction, permutations and combinations.

3) Finite Mathematics (mostly Business majors): one or two term or semester course often requiring college algebra as a prerequisite.

Course Description: Counting and probability; matrices; vectors; linear programing using geometric methods and the simplex algorithm; game theory.

4) The Calculus Sequence: A 2-5 term or semester course for students who have had four years of high school mathematics with SAT scores of 580-625 or ACT (Math) scores of at least 31.

Calculus and Analytic Geometry

Course Description: Derivatives; curve sketching; definite and indefinite integrals; area; volume; transcendental functions; vector analysis; solid geometry; partial differentiation; multiple integrals; infinite series; power series.

Calculus for Business or Social Scientists

Course Description: Single variable calculus with an introduction to several variables, with applications from business and social science.

Note: In some universities and colleges, "collegiate mathematics" refers to courses in calculus (or calculus and analytic geometry), probability and statistics, finite mathematics, and higher level mathematics courses.

3.2 CRITERION FOR MATHEMATICS PLACEMENT OF ENTERING FRESHMEN

Once a high school student has been admitted to a Michigan college or university, he/she must then "be placed" in the appropriate level of mathematics. In some colleges or universities this placement is done for all entering freshmen whether or not they register for a mathematics course their first term. The placement procedure may take any one of the following forms.

1) A placement examination for mathematics which is given to all incoming freshmen, the results of which are used to advise students regarding appropriate courses to elect.

2) The ACT or SAT mathematics scores and high school grades.

3) High school grades in mathematics and years of mathematics may be used alone or in conjunction with SAT or ACT scores.

4) Some combination of 1, 2, and 3.

For example, Michigan State University uses a placement examination to determine incoming students' proficiency in English, arithmetic and algebra. The score on the arithmetic and algebra placement test is used as a guide in placing students in the appropriate mathematics course. Table 3.1 contains a summary of the placement examination scores for the 1977 fall freshmen by sex and college (major).

Students entering MSU are made aware of the prerequisites for various mathematics courses. They are offered counseling if they so choose. Frequently, however, this placement procedure is rather loose. A student could, in many circumstances, take the course for which he/she feels ready even if the placement procedure recommended a different course. Other institutions exhibit similar looseness, and in the placement procedure, colleges and universities allow students to change course selections (usually lower level) early in the term with no penalty. The student who changes elections is responsible for studying the missed part of the course on his/her own. Clearly this is a difficult situation for the weaker students, but it is one which could be avoided if the student wished to.

Table 3.1

Academic Majors Selected by MSU Freshmen
and Their Performance on
Arithmetic, Mathematics and English Placement Examinations for
Fall 1977

	New Students	Low E[a]	%E of total	Low A[b]	%A of total	Low M[c]	%M of total
Freshmen	7153	987	13.8	932	13.0	3154	44.1
Male	3308	437	13.2	280	8.5	1189	35.9
Female	3845	550	14.3	652	17.0	1965	51.1
No Preference	1654	209	12.6	226	13.7	759	45.9
Ag and Natural Res.	343	35	10.2	40	11.7	152	44.3
Arts and Letters	327	28	8.6	62	19.0	197	60.2
Business	999	170	17.0	117	11.7	473	47.3
Communication	309	36	11.7	68	22.0	216	69.9
Education	200	55	27.5	54	27.0	135	67.5
Engineering	580	94	16.2	29	5.0	117	20.2
Human Ecology	162	36	22.2	47	29.0	114	70.4
James Madison	202	11	5.4	25	12.4	99	49.0
Lyman Briggs	252	17	6.7	7	2.8	36	14.3
Natural Science	993	155	15.6	108	10.9	361	36.4
Social Science	508	75	14.8	109	21.5	301	59.3
Veterinary Medicine	529	49	9.3	31	5.9	154	29.1
Human Medicine	94	17	18.1	9	9.6	39	41.5
Urban Development	1	-	-	-	-	1	-
TOTAL	7153	987	13.8	932	13.0	3154	44.1

[a]E = No. required to take Remedial English
[b]A = No. required to take Arithmetic
[c]M = No. required to take Remedial Algebra (if the major requires math)

	M-F Ratio 1975	1976	1977
Fr. Pop.	46-54	47-53	46-54
E Pop.	39-61	44-56	44-56
A Pop.	25-75	27-73	30-70
M Pop.	34-66	36-64	38-62
Def Pop.		37-63	39-61

Prepared by Dr. Myron Miller, Coordinator, Improvement Service 10-77

3.3 A PROFILE OF THE HIGH SCHOOL ACADEMIC BACKGROUND OF REMEDIAL STUDENTS

A study was done at Michigan State University by Lappan and Phillips[1] on the backgrounds of students taking the following mathematics courses during the fall term 1977: Remedial Math I (Elementary Algebra), Remedial Math II (Intermediate Algebra), College Algebra and Calculus. Samples of 135, 376, 131, and 161 students respectively were used. The samples were partitioned on the basis of 1) high school grade point average (HSGP), 2) high school mathematics grade point (H.S. Math GP), 3) years of high school mathematics and 4) the level of Algebra I taken. The data for each course are reported in Tables 3.2, 3.3, 3.4 and 3.5.

About 70% of each group were freshmen. In Tables 3.2 and 3.4 it should be noted that all groups had a HSGP of more than 3.0 and at least 2.34 years of high school mathematics. These characteristics have traditionally been considered sufficient for admission to a college. However, there were many students (62%) who had had three to four years of high school mathematics and yet found themselves enrolled in Remedial Math II courses (Table 3.4). Their overall high school math grade point was below a B (2.73) average (Table 3.3), which seems to be a deciding factor. For example, in the college algebra group 75.6% took three to four years of high school mathematics and their mathematics grade point was a B (3.02) while in the calculus group, 91.9% took three-four years of mathematics and had a math grade point B+ (3.47).

An interesting phenomenon occurred with grade points in all the groups except calculus. The HSGP is higher than the HS Math GP. In the calculus group more students have a 4.0 average in mathematics than in their overall grade point average (Tables 3.2 and 3.3).

The data in Table 3.5 is of interest because as one proceeds through the groups, the percent of students who took college preparatory mathematics increased from 25.2% in Remedial Math I to 52.3% in Calculus. Indeed, as one proceeds through the mathematics groups from Remedial I to Calculus, the HSGP, HS Math GP and years of mathematics taken all increase.

It can be concluded that the number of years of high school mathematics together with the high school mathematics grade point were a good predictor of whether a student starts with Remedial Math or with a Pre-Calculus course. A student with at least three years of high school mathematics (taken at

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[1] MSU uses an algebra placement exam to determine the appropriate math course for all freshmen. The placement exam roughly requires one to one and one half years of H.S. algebra. The study was done by Dr. Glenda Lappan and Ms. Elizabeth Phillips in 1976 and 1977.

the college preparatory level) with mathematics grades of 3.02 and overall grade point of 3.19 will probably not start with a remedial mathematics course.

Table 3.2
HSGP

Math Students enrolled in 1977 fall term	4.0 A	3.5 A-/B+	3.0 B	2.5 B-/C+	2.0 or below C or below
Remedial I (Elem. Alg.)	*1.5	31.1	47.4 Ave. 3.07	17.8	1.5
Remedial II (Intermed. Alg.)	2.4	30.9	49.2 Ave. 3.09	16.5	0.5
College Alg.	4.6	45.8	34.4 Ave. 3.19	13.7	0.8
Calculus	19.9	46.0	26.1 Ave. 3.40	7.5	0

Table 3.3
HS Math GP

Math Students enrolled in 1977 fall term	4.0	3.5	3.0	2.5	2.0 or below
Remedial I (Elem. Alg.)	*3.0	8.9	26.7 Ave. 2.67	40.0	20.7
Remedial II (Intermed. Alg.)	2.9	13.0	29.3 Ave. 2.73	36.4	17.8
College Alg.	9.2	21.4	38.2 Ave. 3.02	23.7	6.9
Calculus	37.3	34.2	14.9 Ave. 3.47	12.4	1.2

*All numbers are in percent.

Table 3.4

Math Students enrolled in 1977 fall term	Years H.S. Math (8th-12th) excluding arithmetic 0-1.5	2-2.5	3-3.5	4 or more
Remedial I (Elem. Alg.)	*22.2	40.0 Ave. 2.34	29.6	8.1
Remedial II (Intermed. Alg.)	6.1	31.1 Ave. 2.94	37.8	24.5
College Algebra	3.8	19.8 Ave. 3.29	32.1	43.5
Calculus	1.2	6.8 Ave. 3.66	24.2	67.7

Table 3.5

Level of Algebra I

Math Students enrolled in 1977 fall term	General	College Preparatory	Algebra for slow learners	Only one track offered
Remedial I (Elem. Alg.)	*40.0	25.2	12	33
Remedial II (Intermed. Alg.)	37.8	32.8	3.2	25.8
College Alg.	20.6	41.2	4.6	31.3
Calculus	19.3	52.8	1.2	26.1

*All numbers are in percent.

3.4 MATHEMATICAL WEAKNESSES OF ENTERING COLLEGE FRESHMEN

It should be pointed out that the mathematics competencies students should have upon entering college have not changed significantly over the past 25 years. This should be evident from the description of college mathematics courses reported in section 3.1. It was also shown that college freshmen have had, on paper at least, two years of high school math and that the majority at the four year colleges have had three years of math and an overall grade point average of 3.0--the traditional requirements for entrance into college.

After lengthy deliberations this committee decided not to publish a list of algebraic or geometric skills and concepts in which students were deficient. Some of the reasons for this decision are: Every professional has his/her own list and agreement on THE list is impossible. Whenever a list of minimal objectives is published, it tends over a period of time to become a list of maximal objectives.

There is a tendency to think of objectives in a list as independent of each other. Furthermore, several lists of objectives (skills and concepts) already exist. See Bibliography.

On the other hand, the high school teachers with whom the committee talked have demanded, justifiably, some specific comments on the nature of the mathematical weaknesses which entering college freshmen exhibited. The following discussion is an attempt to respond to this need for specifics, without in any sense making curriculum suggestions for high school faculty.

Therefore, rather than a list of objectives this committee decided to give a sample of errors or weaknesses made in college freshman math courses and to discuss possible reasons why these errors persist. Hopefully all of us who are teachers of mathematics will contemplate the sources from which these errors arise and take the appropriate action to prevent the propagation of mathematical errors, frustrations, and failures which inhibit the healthy growth of a mathematical mind in all our students at all levels.

Simple to complex: Many students can solve a problem as long as the patterns are simple, but do not recognize the same pattern if the situation becomes slightly more complicated.

Example 1:

Simple pattern: $x + 2x = 3x$

Complex pattern: $(a + b) + 2(a + b) = ?$

$\sqrt{2} + 2\sqrt{2} = ?$

Example 2:
Simple pattern: $x^2 + 5x + 6 = 0 \Rightarrow x = -2$ or $x = -3$
Complex pattern: $(x - 3) \cdot (x - 2) = 20 \Rightarrow ?$

Example 3:
Simple pattern: solve for x: $x + 3 = 7$
Complex pattern: solve for x: $|x| + 3 = 7$
$x + a = b$
$\log_{10} x + 3 = 7$

Example 4:
Simple pattern: it is easy to go from $-2(x + 3)$ to $-2x-6$
Complex pattern: but when parentheses and negative signs appear within another problem as in algebraic fractions or in combining polynomial expressions, they are often ignored or mishandled.
Solve for x: $3 - 2[x - (3 - x)] + 3x = -(x - 1)$

Reversing Processes:

Example 1: We often ask students to graph $y = -x^2 - x + 2$. But given a graph of a parabola which represents, let's say, the path of water from a fountain, we should ask students such questions as how high the water is projected. At what time is the water n feet from the ground? What is the equation of the given parabola? etc.

Example 2: Often mathematical laws are taught in one direction: for example the distributive law $a(b + c) = ab + ac$. The reverse process is also important. Students should be taught to recognize that this law comes in many disguises:

$$1 - \frac{x+2}{x^2-3} = \frac{x^2-3-(x+2)}{x^2-3}$$

and $x-1 = -(-x + 1) = -(1 - x)$ and $x^2 - x + 3x - 3 = x(x - 1) + 3(x - 1) = (x - 1)(x + 3)$. Students should also recognize operations for which a distributive law does not apply:

$$\sqrt{a^2 + 4} \neq a + 2$$

and $(x^2 - 2)^{-3} \neq x^{-6} + (-2)^{-3}$

Example 3: The fundamental theorem of fractions states: If $x \neq 0$ then $\frac{ax}{bx} = \frac{a}{b}$. Most students recognize this theorem from left to right (or reducing to simplest form), but fail to recognize it in the opposite direction as when it is used to exhibit the LCD.

Example 4: Students can solve for x in $x^2 + 5x + 6 = 0$ but given $x = 2$ or $x = 5$, they can not find an equation with these solutions.

Distinguishing factors and terms: The fact that a student will do the following correctly: $\frac{2x}{3x} = 2/3$ $\qquad (ax)^3 = a^3x^3$

and the following incorrectly:

$\frac{2 + x}{3 + x} = 2/3$ $\qquad (a + x)^3 = a^3 + x^3$

$\frac{2 + \sqrt{x + 1}}{3 + \sqrt{x + 1}} = 2/3$ $\qquad -2x(x^2y) = -2x^3 - 2xy$

shows that he/she does not understand either the distributive law or the fundamental theorem of fractions. The distributive law should be taught as a way to write a product of factors as a sum of terms and conversely. Students should readily recognize when $x + 3$ is to be thought of as a sum of two terms and when it is to be thought of as a factor as in $2(x + 3)$. A student should be able to think of $3x^2$ as a number, as a product of two or three numbers or a number in factored form depending upon the situation.

Distinguishing between expressions and sentences: Separately a student may be able to solve: $\frac{x^2}{3} - \frac{x}{5} = 1$ for x

and simplify: $\frac{x^2}{3} - \frac{x}{5} - 1$

But when the two problems appear on the same test or within the same problem, denominators may disappear in $\frac{x^2}{3} - \frac{x}{5} - 1$ and remain in $\frac{x^2}{3} - \frac{x}{5} = 1$.

Relating ideas: This is similar to going from simple to complex patterns. Many students can solve $x^2 + 3x + 2 = 0$ but fail to see any connection between this equation and the equation $y = x^2 + 3x + 2$. Other students assume that the two are the same.

Applications: The teaching of word problems has always been difficult. Since so many students dislike them intensely, it is often easy to ignore them. However, while a major proportion of an algebra course is spent on developing skills and concepts, it should be kept in mind that skills and concepts are necessary but not sufficient knowledge for continued success in math. Word problems and all questions asking students to give verbal meaning to symbolic statements and conversely (not a regurgitation of a definition) are steps forward in fulfilling the sufficient condition. A student must be able to use his/her algebraic skills to solve applications which appear in his/her chosen field and to recognize the importance of mathematics in the world around him/her. An effort should be made by teachers to seek out meaningful applications. Many problems in books are totally unrealistic or boring. (Age problems come readily to mind.) Students should be encouraged to use their common sense. For example, a business student was asked to find the number of years it would take to double an investment of $500 at 6% interest a year. It did not occur to him that his answer of 300 years was unreasonable.

Algebra versus Geometry: Finally, more connection should be made between these two areas. Students need to visualize algebraic concepts geometrically.

Example 1: Students should not only be able to graph, but when given a graph they should be able to read information from it.

Example 2: A student should be asked not only to graph $|x - 2| < 3$ on a number line, but also to write an English statement describing $|x - 2| < 3$ as distance on a line.

Example 3: A student should be able to describe the role of 'a' as he/she goes from the graph of $y = x^2$ to the graph of $y = ax^2$.

Example 4: The expression $x^2 + 5x + 6$ can be interpreted as the area of a rectangle with dimensions $x + 2$ and $x + 3$.

Example 5: Geometric concepts such as perimeter and volume of common geometric figures, the properties of congruence, parallelism, similarity and perpendicularity should be translated into algebra, and conversely the algebraic statements into geometric concepts.

Every teacher has his/her own horror stories. The above list could go on and on. These examples are cited merely to give the flavor of the problem in some of its various guises.

Sources of errors: Many of the errors students make indicate that they have been memorizing algorithms or definitions with very little understanding. The situation is similar to a non-Arabic speaking person attempting to write an Arabic sentence by picking Arabic words at random from a dictionary. It may come out as nonsense. Indeed, mathematics is also a language. The symbols are the foreign language, and a symbol should provoke an idea or thought in the person's mind if that person is to be mathematically literate. All efforts to have students integrate, analyze, process, organize, synthesize, estimate and relate old ideas to new ideas are steps forward in achieving proficiency in the language of mathematics. The mathematics teacher should accept as a personal and professional goal the commitment to helping students understand.

CHAPTER IV

CHARACTERISTICS OF UNDERPREPARED STUDENTS AS SEEN BY COLLEGE FACULTY, HIGH SCHOOL TEACHERS, AND STUDENTS

4.1 COLLEGE FACULTY

The 1976 survey described in section 1.1, asked the college faculties to comment on possible causes for the increased number of remedial mathematics students. The following possibilities (which are also frequently listed in the literature of the subject) were given:

1. poor study habits and skills
2. poor reading and composition skills
3. failure to attend class regularly
4. failure to complete tasks or assignments on time
5. grade inflation at high school and college levels
6. minimal state and high school math requirements for high school graduation
7. minimal college entrance requirements
8. increasing math requirements for degree programs
9. avoidance of math by low achievers in high school (with counselor's advice)
10. more students entering college who have not planned an appropriate high school program to allow for options in their choice of a college career
11. increasing age of students in community colleges
12. increasing job orientation of students resulting in more students choosing curricula (e.g., engineering, nursing, business) requiring more math because the jobs are there
13. several "levels" of high school algebra resulting in "watered down" courses for the lower levels

4.2 HIGH SCHOOL TEACHERS

From the evidence presented in preceding sections it is clear that the average college freshman is less prepared in mathematics than he/she could be. Furthermore, the situation seems worse today than it was a few years ago. If some college teachers feel that the level of preparation of entering freshmen has declined, do experienced high school teachers hold a similar view? Do they see a change over the years? Specifically, do

they see a difference during the last twenty years in the courses offered, in the demands made on students, in the preparation of students entering high school, or in the students themselves? The committee interviewed several high school teachers, each with at least twenty years of teaching experience and held discussions with groups of high school teachers over the past two years. The following are comments which were made several times to the question: What do you think is the reason for the declining state of mathematics preparedness of high school graduates?

1. The breakdown of the family--one parent home or both parents working--which results often in a lack of discipline.
2. Disrespect for adult authority and experience.
3. Low self-image on the part of the student.
4. Parental pressure to take college preparatory courses. This results in schools offering several levels of college preparatory math courses. Teachers are not surprised that students with three years of mathematics (if it was taken at the second or third level) and with only C+ in mathematics end up in remedial algebra courses in college.
5. Standards for Algebra I in high schools have been lowered because more and more bright students take Algebra I in the eighth grade.
6. Standards are still high for the top level college preparatory courses.
7. A grade of C is commonly given out to reward good behavior, attendance, or trying hard but not knowledge.
8. Students are less prepared in elementary and junior high schools.
9. Too much focus on minimal objectives.
10. Inefficient use of study times.
11. Too many outside demands on students' time.
12. Students are over-programmed--they do not have time to think for themselves.
13. Subtle pressures from administration on teachers not to give too low of a grade.
14. Many students in Algebra II classes cannot do the basics from the Algebra I course.
15. Fewer comprehensive exams are given than in the past. The result is a topic is learned and forgotten.
16. Students cannot read mathematics books.

17. More pressure on schools and teachers to correct society's failures, e.g., behavior problems, mental health, adult figure, discipline...
18. High school teachers' standards and expectations have slipped.

4.3 THE STUDENT

There has been much discussion about the causes of the large number of remedial math students at the college level by administrators, teachers and parents. Little attention, however, has been paid to what the student thinks. In an attempt to find out how students felt about their pre-college training, the committee interviewed several freshmen enrolled in either remedial math or calculus. In addition, a survey by Lappan and Phillips was made of each of the following groups of mathematics students at Michigan State University: remedial math I (135), remedial math II (376), college algebra (131), and calculus (161). At least 70% of each group were in their first year of college. The major results of this are listed below.

1. Each mathematics group had equal representation from inner-city, suburban and small town high schools.
2. About 50% of the students came from high schools requiring only one year of high school mathematics and another 25-30% came from schools requiring two years of high school mathematics. (The survey did not specify whether General Mathematics counted as one year or not.)
3. Twenty-five percent of the Remedial I group, 33% of Remedial II group, 54% of College Algebra group and 85% of the Calculus group took a college preparatory Algebra I course in high school. About 20% of each group indicated there was only one level of Algebra I in their high school.
4. Both of the remedial groups indicated that it had been too long since their last mathematics course.
5. All of the groups indicated that the high school counselor had little to do with which algebra I course they took. However, most of the remedial students claimed their counselor did not encourage them to take more mathematics.
6. All groups strongly agreed that homework was regularly assigned to be completed outside of class.

7. The remedial group indicated a stronger disagreement with the statement, "I seldom finished my homework" than did the college algebra or calculus group.

8. The remedial groups (35%) tended to agree with the statement, "Most of the mathematics teachers were not very good" as compared to 15% of the upper two groups. The college algebra and calculus groups disagreed (60%) more strongly with the statement.

9. The remedial groups agreed one had to work hard to get a "B", while the college algebra and calculus groups tended to agree that little work was required to get a "B".

10. More remedial students (42%) than calculus students (10%) tended to agree with the statement, "I was not aware that I would need mathematics for my chosen career."

11. Most of the remedial groups agreed that mathematics had always been hard: 59% remedial I, 79% remedial II, 35% college algebra and 13% of calculus group.

12. Good students claimed to have cut mathematics class more than the remedial groups.

13. Twenty-five percent of the remedial groups said they would have chosen a different career if they had been better at mathematics, compared to 8% of the calculus group.

14. The percent of agreement with the statement, "I have never liked math and it is my most dreaded subject" is 52%, 34%, 27% and 8% for the four groups respectively.

15. All groups agreed they would like to develop their mathematics skills and study the subject more.

16. All groups indicated they studied mathematics about one-half to one hour per day in high school and one-two hours a day in college with fewer students tending to put off studying to the last minute in the college algebra and calculus groups.

It is interesting to note that the interviews supported the MSU survey results. In particular, the following characteristics of the weaker student were supported by the interviews. They did not take college preparatory versions of their high school mathematics or at the very most a lower level of college preparatory mathematics. The weaker students did not do very well in mathematics (C or C+) and were quicker to blame their teachers and counselors for their poor performances and attitudes in mathematics.

CHAPTER V
RECOMMENDATIONS

After many discussions with college and high school faculty and students, the following recommendations are made by the committee as steps that might be taken by all persons involved in the education of young people--parents, school boards, superintendents, principals, teachers at all levels--which would improve basic mathematical skills and understandings and allow the career options of young people to remain more flexible in the future.

Recommendation 1: Counselors need to help students become more aware of the relevance of the high school mathematics program to their post-secondary school opportunities.

a) Mathematics provides important foundations which may be required for many college programs and majors, even in subject areas not commonly viewed as mathematical.

b) General college entrance requirements often differ from college graduation requirements. At the present time many colleges (particularly in the East and West) are contemplating implementing Core Curricula. For example, Harvard University has recommended as the Science and Math part of its proposed Core Program for all students one course in the physical sciences (which includes mathematics) and one in the biological or behavioral sciences emphasizing fundamental principles, rather than the broad survey usually found in introductory courses. In addition students must have demonstrated competence in algebraic manipulations before taking their science and mathematics courses (Wall Street Journal, January 3, 1978).

c) Students frequently do not decide until late in high school or beyond what careers they want to pursue, but by taking three or four years of high school mathematics, they can keep their options open.

d) High school experiences and achievement affect student options for college programs, ability to succeed in these programs, and the cost and length of time needed to complete these programs.

e) At present, the best job opportunities are with majors which have some college mathematics required.

f) Students should be encouraged to plan high school programs that include courses which provide background appropriate to their goals, capabilities, and the current demands of careers--specifically college majors.

g) The counseling procedure (and all persons involved in the education of young people) should provide special encouragement for minorities and women to keep their options open by studying mathematics at the high school level.

Recommendation 2: Teachers need to improve their teaching effectiveness as measured by student performance and attitude.

a) It is not enough just to take the courses in mathematics; students should strive for and teachers should emphasize attaining skill and competence in mathematical thought and problem solving.

b) In mathematics courses teachers should emphasize comprehension of fundamental principles--the integration of algebraic and geometric ideas, and the application of these principles in realistic contexts.

c) Develop manipulative skills based on understanding of underlying concepts.

d) More time should be spent in developing motivational devices. Mathematics should be taught as a continuing process, stimulating the imagination and playing upon the natural curiosity of students.

e) Students should learn perseverance. Some of the mathematics problems given to students should yield answers only after a substantial amount of thought.

f) Students should be given specific help in how to study and read mathematics. Many students put in time studying, but the time is not used effectively. Students should be put in situations where the use of a variety of techniques and strategies in problem solving, and the relating of procedures and ideas from a variety of mathematics topics are necessary.

Recommendation 3: Administrators and parents need to increase their support of the counselor and teacher.

a) Integrity in the evaluation and grading process needs to be reestablished. This can only be done by a determined effort made by all teachers and backed by parents and administrators.

b) Administrators and parents should support (indeed insist) on the pursuit of excellence in all areas of high school.

c) Parents must impart to their children a serious commitment to academic achievement by providing guidelines and positive encouragement in the home.

Recommendation 4: The mathematics curriculum needs to be evaluated.

a) Mathematics courses should be realistically named. Algebra I, Fundamental Algebra or Living Algebra should be called General Mathematics or something appropriate, if indeed it is not an Algebra I course.

b) Most teachers support homogeneous classes. This is fine provided that all students who have Algebra I and Algebra II on their record have mastered the minimum topics for those courses.

c) There should be an opportunity for students who have either avoided or taken mathematics in 8th or 9th grades to take review courses later in their high school careers.

Recommendation 5: Colleges must review their responsibilities concerning the underprepared student in mathematics.

a) Colleges should recognize that low admissions standards undermine high school standards.

b) Colleges should involve experienced high school teachers in a comprehensive evaluation of teacher preparation programs.

c) Colleges need to increase their communications with high schools concerning enrollment patterns and academic performance of high school students.

d) Colleges need to realistically distinguish between college entrance requirements and college graduation requirements when communicating to high schools.

Recommendation 6: College and high school faculties need to establish a means for continuing communication between professionals at the high school and college level to help each other with problems pertaining to the mathematical preparation of students.

In conclusion, the committee would like to quote from the "Guidelines for Improving SAT Scores". "...the schools who have maintained SAT scores at or above the 1965 level believe that college-bound students should face a moderately stiff curriculum, be counseled as to its value, be supported in its attainment, and be examined on its outcomes."[1]

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[1]This was a study done on 34 high schools with stable or rising SAT scores from 1966 to 1977 by the National Association of Secondary School Principals, Reston, Virginia.

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